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A Dissertation

Presented in Partial Fulfillment
of the Requirements for the Degree

DOCTOR OF EDUCATION

College of Education

Arizona State University

by

Thomas Edward Thorpe

June 1965

AN INVESTIGATION IN ELECTRONIC TRANSLATION OF PRINTED MATERIALS INTO AUDIO-RESPONSES TO FACILITATE THE TEACHING OF READING TO THE VISUALLY HANDICAPPED

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Date

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I. STATEMENT OF THE PROBLEM

The objective of this study was to develop and perfect a small, compact, electronic audible response device, that would assist blind people to read selected printed materials printed on conventional paper. The widely divergent tones produced by this device in response to various portions of printed characters in the upper case alphabet, enables blind people to distinguish audibly, the letters of the alphabet. These audio-responses were within the range of human hearing capacity as identified by the Fletcher Munson Study of Human Hearing Acuity.

The investigator formulated a method of teaching this audio-language to a selected sample of visually handicapped elementary children by relating the tactile configuration of the printed characters to their converted audio-representations.

II. METHODS AND PROCEDURES

The investigator selected word combinations identified by the Bell Telephone Laboratories as the ten most frequently used words in the English language.

The investigator obtained a selected sample of legally blind pupils. The audio-responses for the selected words were then taught to these pupils as related to the tactile configuration of the word. Each pupil was taught and evaluated as an individual case.

The _Maico Audiometer Sweep Check Test of Hearing Acuity_ was administered to each participating pupil in order to determine that their hearing acuity was sufficient for this study.

The pupils selected for participation in this study were academically highly endowed.

Audio-identification was limited to the following words and their respective combinations: "I, the, a, it, to, you, of, and, in, and he."

The symbols three-eighths of an inch in height were restricted to the upper case of the alphabet.

III. FINDINGS

The hypothesis investigated was: Visually handicapped children can learn to interpret printed materials via audio-responses. Within the limits of the investigation, the results were in agreement with the hypothesis.

The investigator developed a compact, portable, electronic translator. The input of this device was selected printed material. The visually handicapped individuals selected for this study used a hand-held reading probe. The probe was caused to move from left to right across the printed symbols in much the same manner utilized by a sighted person when reading.

The investigator found that the visually handicapped were able to relate the tactile configuration of large cardboard letters to identify printed symbols when translated by the audioscope into audio-response.

The training procedures used in this investigation, were an effectual approach in that they enabled the visually handicapped child to read selected printed materials via audio-responses.

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THE PROBLEM AREA

I. INTRODUCTION

The purpose of this study was to provide additional knowledge of modern advances in the fields of electronics and optics as these advances are related to the problem of the visually handicapped child.

Formerly, the teaching of reading to the visually handicapped has been centered on the use of braille. This study was undertaken to explore the use of electronics in converting visual material to a sound equivalent.

The two aspects of the problem investigated were:

1. determining a means of integrating the black and white ratio of each letter or group of letters or symbols into a sound that could be understood in much the same fashion as International Morse Code is understood.
2. devising a plan to teach these audio-responses to individuals deprived of sight.

Statement of the problem. The purpose of this study was to investigate the conversion of upper case letters as they appear in printed materials into an audio-response; then to teach these audio-responses to the visually handicapped child as a method of reading print.

Need for the study. If the visually handicapped child is to be integrated into the public school, he must be able to explore the printed page in terms of meaning.

The Library Research Service of the Encyclopaedia Britannica provided the following statistics on Braille Readers.

> Under the Federal act, "To Promote the Education of the Blind," (amended by Public Law 922, 84th Congress), the American Printing House for the Blind in Louisville, Kentucky, makes available special materials and apparatus for the education of blind children enrolled in public and local and residential schools. These aids are distributed on a per child quota allotment basis. To be eligible under the provisions of the act, it is required that children be registered annyally by their schools or State education departments with the American Printing House for the Blind. Each child's visual impairment must be such as to render him legally or officially blind.
>
> Possibly, more than 90 per cent of the legally blind children in the Nation who are without major second handicaps, who are in serious need of special education, and who are enrolled in public local or residential schools are registered each year under this act so that the schools they attend may obtain allotments of special aids and materials for use in their education. For the 1959-60 school year, as of January 1960, more than fourteen thousand five hundred children were registered. This group of children, therefore, represented a vast readymade cross-section of the Nation's legally blind school-age population. Through the courtesy of officials at the American Printing House for the Blind, data concerning them were made available to the Office of Education for tabulation and analysis. The total registration with the American Printing House for the Blind was about fourteen thousand five hundred seventy children, with adult rehabilitation cases removed. The study includes information on fourteen thousand one hundred twenty-five children, or approximately 97 per cent of the total register.
>
> Analysis of the mode of reading of the children covered by this report in relation to their degree of vision revealed several predictable trends. If the degree of remaining vision is an important factor in determining mode of reading, the distribution

> would lead to the prediction that most of the children would be registered as readers of either print or braille, and few would be reading both. This prediction seems to be borne out by the finding that approximately 58 per cent of the 14,125 children are registered as using braille, and 38 per cent as using print for their primary mode of reading. About 4 per cent are registered as readers of both print and braille. Similarly, on the basis of this hypothesis, one would expect to find that most of the readers of print have the best vision and are in the upper classifications, and most of the braille readers are in the lower classifications.[1]

This report further states that Braille seems to present a major problem to many teachers who accept the challenge of guiding the educational program for blind children. The uninitated find the pattern of embossed dots a bewildering maze, and its tactual perception little short of a miracle. There are 188 characters of the Braille code, many of which have several different meanings according to their relative position to other characters. The teacher who attempts to master these characters, and to develop even a little tactual acuity during one short intensive training course in his or her teaching training program, finds it equally as bewildering as the children do. The mastery of Braille seems to be such a great undertaking that it becomes an end in itself. Teachers therefore, are likely to lose sight of the fact that Braille is merely a tool for the important process of communication of ideas.[2]

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[1] Encyclopaedia Britannica Library Research Department, Library Research Service, V.A. Stenberg, Director. (unpublished report, "Stastics on Braille Readers," p. 1.

[2] Ibid. p. 2.

Braille is not taught. Reading and writing are taught, and Braille is only a medium through which experiences are shared. Whenever a child has reached the level in his growth pattern during which he is interested in beginning to share ideas through written symbols, he is ready to begin to use his medium for this skill--whether it is ink print or Braille.[3]

When the child enjoys listening to stories he is ready for a very important experience with Braille.

> Just as the child with vision discovers that his favorite story is in a book of some certain shape and is communicated to him through some strange-looking little black marks, so the child who is blind is ready to appreciate the fact that his favorite story is found in a certain book and is communicated to him through some little bumps that tickle the fingers.
>
> This valuable experience of associating his favorite stories with the medium through which they are communicated may, for the blind child, be delayed until he enters school. His wise teacher, even though she usually reads from ink print, will let him discover that she reads some of his stories by moving her fingers across raised dots on the page. She will create some little books, attractive to inquisitive fingers, in which the child can make the thrilling discovery that certain dots say, 'I'll huff, and I'll puff, and I'll blow your house down.' It is a wonderful occasion when he can read these all by himself.
>
> An appreciation of the fact that the little bumps say something--that interesting information, exciting adventures, and lots of fun are communicated through the embossed page--provides a greater incentive for learning to use this medium.
>
> Any child must evidence a certain level of maturity--socially, emotionally, mentally, and physically--before he is ready for intensive interest in written communication. It is often true that environmental influences have restricted the normal growth and development of the handicapped child.[4]

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[3] Ibid., p. 5

[4] Ibid.

The handicapped child is often frustrated by too much help from an oversolicitous family. He feels that he cannot do much for himself and that he is not worth much as an individual. The child who is thus frustrated needs many experiences to help him to develop a wholesome self-concept. He needs to experience the satisfaction that comes from achieving for himself and for others. He needs the sense of security that comes with self-confidence. This child needs group experiences in order to discover the joy of a give-and-take relationship.

Many times, a handicapped child suffers from delayed muscular coordination due to inactivity. These conditions of delayed maturation necessitate an extensive and intensive readiness program.

When the visually handicapped child reaches an adequate stage of maturity, he is still not going to learn Braille as a subject. He is going to share experiences, thoughts, and ideas. He is going to learn to read and write. Braille is only his tool, and should be treated as such.[5]

> The rate of finger reading is one factor which the teacher must consider in planning her work. The child who begins to read by learning to recognize large thought units reads more rapidly than does the adult who learns to read through the analytic approach to each character and word.
>
> However, even after skill is developed, the average rate of finger reading is about one-third of the average rate for the sight reading of print. The finger span is not as long as the eye span.

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[5] Ibid., p. 5.

For the beginning Braille readers, the teacher will probably need many guide questions so that the child reads only a short thought unit to find the answer to each. He will not cover as much material in one lesson as will the sighted child.

The teacher must, in planning her work, also take into consideration the element of fatigue. A day's activities demand a great deal of nervous energy on the part of the blind child. The teacher needs to watch for signs of fatigue and to adjust the schedule accordingly. The child may need frequent short periods of work rather than longer periods requiring sustained attention.

These factors of rate and fatigue have another implication for teachers. As the child progresses in school, his Braille reading may need to be supplemented by tapes and recordings of other kinds in order for him to cover a wealth of material. However, the teacher must never lose sight of the fact that Braille is the child's unique tool for communication, and he should develop to his optimum his skill in its use.[6]

It was not the purpose of this investigation to state or infer that the optophone could or would replace Braille, but to show that the optophone could be a valuable supplement to the visually handicapped by enabling them to enrich their lives through broader experiences, and through these experiences to build self confidence and a more wholesome self-concept.

The concept of the optophone is not new. However, the device has not been used as an every day teaching and reading tool. The sightless child reads today, as in the past, by means of Braille.

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[6] Ibid., p. 6.

II. THE PROBLEM

The basic elements of the problem devised for the research study, "An Investigation in Electronic Translation of Printed Materials into Audio-Responses to Facilitate the Teaching of Reading to the Visually Handicapped," includes: (1) statement of the problem, (2) delimitation of the problem, (3) evaluation of the problem, and, (4) technique to be used in the study.

Statement of the problem. The problems of this investigation were:

1. To develop a small, compact electronic audible response device that would assist blind people in the reading of printed characters.
2. To perfect this device so that letters or other indicia printed on conventional paper could be readily distinguished audibly by widely divergent tones produced by the device in response to various portions of printed characters in the upper case of the alphabet. These audio-responses are within the range of human hearing capacity as identified by the Fletcher-Munson study of human hearing acuity.

3. To formulate a method of teaching this audio-language by relating the tactile configuration of the printed characters to their converted audio representations.
4. To teach this system to a sampling of visually handicapped elementary school children who are integrated into the public school systems located in the Phoenix Metropolitan area.

Hypothesis. The hypothesis investigated was: Visually handicapped children can learn to interpret print and other indicia via audio-responses.

III. DELIMITATION OF THE PROPOSED RESEARCH

The delimitations of the research study were as follows:

1. This research was limited to the printed alphabet.
2. The study further was limited to letters in the upper case, three-eighths of one inch in height, printed with black printers' ink on a white surface.
3. Word combinations used were those identified by the Bell Telephone Laboratories consisting of the ten most frequently used words in the English Language, "I, the, a, it, to, you, of, and, in, and the."

IV. ASSUMPTIONS INHERENT IN THE STUDY

The development of pupils who will participate in, and contribute to the democratic way of life to the maximum of their abilities is an objective of American education. To help children attain this objective is the responsibility of the public schools.

The investigator assumed that visually handicapped children could utilize their sense of hearing to interpret printed materials by converting these printed symbols into recognizable language through the use of selected audio-responses.

The investigator also assumed that the advance of electronics in the past few years will now allow the development of a compact, portable, inexpensive, translator that is capable of producing audio-responses from selected printed material.

V. EVALUATION OF THE STUDY

The need and value of the study. The only method of reading that really is available to the blind is based on the technology of Louis Braille; technology that has changed little since it was developed in 1829. Braille has been an excellent system, but the limitations

of this slow and very expensive method no longer can satisfy the longing of the blind to read for themselves the world of current written material now denied them.

If the visually handicapped child is to be integrated into the public school, he must be able to explore the printed page in terms of meaning. The sightless child reads today, as he did in the past,. by means of Braille. Materials not translated into Braille are not read.

Children with some residual vision are able to do at least a part of their work with their eyes, and the large print textbooks parallel the Braille text in most instances. Because of many factors, all children cannot learn to read Braille. One of these factors is the lack of touch control and touch sense. Materials of a temporary nature, such as programs and menus are not translated into Braille, and therefore the visually handicapped child is dependent upon someone with sight to read this type of material for him. Another problem lies in the fact that current material, both technical and non-technical, requires a considerable period of time before it is available to the visually handicapped in the form of Braille. Therefore, much of the reading matter now available to the visually handicapped in Braille is obsolete by the time they read it. This is particularly true in the physical sciences of our accelerated space technology.

The objective of the study. The first objective of this study was to develop an electronic device capable of giving highly differentiated audio-responses that could be used to assist visually handicapped persons in reading printed material or indicia by directional attack, or left to right sequence, in much the same manner as does a person with normal sight.

The second objective was to formulate a method of teaching this audio-language to the visually handicapped .

The third objective was to teach a selected number of visually handicapped children to read via this audio-frequency translation of printed materials.

VI. DEFINITIONS OF TERMS USED

Audio-scope. An electronic instrument for the conversion of black and white areas into corresponding audio frequencies.

Bias. In electrical work, a voltage whose principal function is to locate the operating point on the characteristic of a piece of apparatus.

Integrated. Assembling parts together into a whole.

Dyne. The fundamental unit of force in the metric system--a force which, applied to a mass of one gram would give it acceleration of one centimeter per second per second.

Diode. A two-electrode device having an anode and cathode which has marked uni-directional characteristics.

Normal line. A perpendicular or right angle to a given line or direction.

Photoresistors or photo diodes . Semi-conduction devices whose internal resistance varies as a function of light falling off the sensitized surface.

Reading head. The tip of the audio-scope.

Scanning. The process of analyzing or synthesizing successively, according to a predetermined method, the light values of picture elements constituting a picture area.

CHAPTER II

REVIEW OF THE LITERATURE

Until recently, little has been written regarding the use of new devices as a means of assisting the visually handicapped, electronically or manually, in the reading process. Consequently, only a summary of new technological developments is included in this study.

I. LITERATURE ON THE OPTOPHONE

The optophone is a print reading machine invented by Fournier d'Albe in 1912.[1] This device was used as a guiding mechanism to assist the blind person in detecting various concentrations of light energy. Fournier d'Albe's original device was the Exploring Optophone, and the first print reading optophone was demonstrated in England in 1913.[2]

Since 1913, several major improvements in this device have been made, but only a limited number of the machines are available.[3]

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[1]F.S. Cooper, "Research on Reading Machines for the Blind," in P.A. Zahl, Blindness: Modern Approaches to the Unseen Environment. Princeton: Princeton University Press, 1950, pp. 512-543.

[2]John L. Coffey, "The Development and Evaluation of the Battelle Aural Reading Device," Proceedings of the International Congress on Technology and Blindness (March 2, 1960), p. 343.

[3]Ibid., p. 344.

According to Cooper, the optophone is representative of a class of reading machines labeled by him as direct translating, nonintegrating devices. He based his classification on the operation of the device in converting the input into the output.

Coffey states:

> Direct translating, nonintegrating means essentially that when printed material is sampled by the reading device the output of the device is directly and immediately determined by the printed material as a function of both the continually changing contour of the print and the point in time at which it is sampled. The direct translating part of this classification means that the relative location of the contour of the print is indicated to the blind person in the output. In general, devices built up to this time have used relative vertical location of the print contour; however vertical sampling is not the only conceivable use of this feature. The nonintegrating part of this classification. . . refers to the time sampling procedure of the device. Devices that are characteristic of this classification have no integrating-over-time feature. That is, there is an instant-to-instant correspondence in time between the input and the output of the device. The configuration of printed contours representing the input at a point in time determines the output for that time sampling. As the input changes from instant to instant, as it would in the reading task, the output changes in the same temporal manner. In general, direct translating, nonintegrating devices have examined vertical slices of letters from left to right in a temporal sequence. Because of this procedure they have been designated as letter reading machines. [4]

Generally, from an engineering point of view, machines built along a direct translating, nonintegrating principle are the simplest functional reading device for the blind. [5]

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[4] Coffey, loc. cit.

[5] Ibid.

The investigator thought it was wise to review, prior to a brief discussion of its operation, the concept on which the original optophone was invented. The printed material in the first optophone was the input. The audible sounds that resulted were considered the selected output as the device examined the vertical slices of the letter from left to right. The original device was a "white reading" instrument, and in 1920 it was modified or improved and made a "black reading" instrument.[6] Freiberger and Murphy described the modified device as follows:

> This device, (white reading optophone) was improved, and a 1920 patent showed a device for reading back letters by illuminating a vertical section of the letter area with light pulses at five frequencies by holes in five annular zones of a rotating disc. Unbalance in an electrical bridge having selenium cells in two of its arms, one receiving part of the pulsed outgoing light, the other reflected light modulated by the print on the paper, was used to feed to the earpiece an audio signal wherein a low tone corresponded to black at the bottom of the area scanned, with progressively higher tones for black in the upper parts of the area. A mechanical mounting moved the optical system smoothly along the line of type but allowed the user to adjust the horizontal scanning rate to slow the scanning momentarily, or to retrace it if necessary.[7]

II. OTHER DEVICES

After the invention of the optophone, several other direct translating, non integrating devices for the visually handicapped

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[6] Ibid., p. 345.

[7] H. Freiberger and E. F. Murphy, "Reading Machines for the Blind," I. R. E. Professional Group on Human Factors in Electronics, March, 1961, pp. 8-19.

appeared. One notable device was the Visagraph invented by Robert E. Naumberg and described in 1928. Another was the Radio Corporation of America Type A-2 instrument developed by Radio Corporation of America Laboratories in 1946.[8]

According to Coffey, the Visagraph is a direct translating, nonintegrating device utilizing the tactile output. Operationally, the machine makes an enlarged and raised replica of the printed material by embossing aluminum foil. In 1947, the machine was improved.[9]

The Radio Corporation of America Type A-2 direct translating, nonintegrating device for the visually handicapped operates by employing an audible output; however, the overall operation is somewhat different from the optophone in that a vertical sweeping ray of light and a variable frequency oscillator are used. In the sweeping process the vertical sample of the letter is swept from the bottom to the top by the light ray and as the light comes in contact with contours of letters the variable frequency oscillator is turned on by a photosensitive element. The output frequency is determined by the position of the sweeping light ray when it comes in contact with letter contours.[10] Freiberger and Murphy stated in their evaluation of the results that further development and work were needed. They did not suggest abandoning direct-translation devices and did not imply that they should be supplied for all blind persons.[11]

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[8]Coffey, op. cit. p. 344 [9]Ibid., p. 346.

[10]Ibid. [11]Freiberger & Murphy, loc. cit.

Another device that translates printed characters into sound was invented by John S. Amba, Lawrence J. Mason, and David R. Rice. This particular instrument, also called an optophone, was patented November 7, 1961, with patent number 3,007,259. This device transforms printed material, or even hand-printed material, into auditory signals. One advantage that this device has over most similar devices is that it allows the blind or partially blind person to manually guide the pickup in a straight line while scanning the printed page. Another outstanding feature of this device is that it can be used to scan various sizes of print or type within reasonable limitations, consequently, making readily available to the reader a wider selection of printed material. This optophone gives off consistent sounds, although the print may vary for different reading material, a feature which permits the blind person to learn to use the device more rapidly, and to have a wider selection of reading material.[12]

This device consists of a reading probe and a carrying case which contains controls, oscillators, amplifier, and power unit. In the reading process, the optophone works as follows:

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[12]John S. Abma, Lawrence J. Mason, and David R. Rice, Optophone, 3,007,259, patented November 7, 1961, United States Patent Office.

The area to be read is illuminated by a small, medical type lens-end lamps located a short distance from the reading material at the end of the probe. The intensity of the lamps is controlled by a rheostat. A lens, also near the probe tip, projects a magnified image of a portion of the letter being read upon a linear array of photo-conductors mounted in the body of the reading probe. Variable magnification is possible by a provision for adjustment in the distances between the print, lens, and photocells, thus allowing for variations in the size of the print. The portion of the letter image is focused on the photocells so that the image is spread over all of the photocells except the two end photocells,these two photocells are used for tracking purposes, by creating an audio signal different from the ordinary reading audio signal if the probe is placed above or below the printed line, or if, during tracking, it begins to stray from the printed line. The probe moves on rollers placed at the tip of the probe. The axis of the rollers is perpendicular to the tracking line, thus aiding the operator in keeping the probe aligned on the line of print or type. Each photocell picks up a certain part of the black area making up a letter and is connected to, and controls a separate oscillator located in the carrying case. The photocells cause their associated oscillators to produce tones whenever letter segments are present. Depending upon the number of photocells covered, the letters will be translated into a number of tones as the black areas of the letter are encountered. For example, a lower case "l" may give rise to a number of tones simultaneously, whereas a dash or hyphen would give rise to a single tone.[13]

III. LITERATURE ON THE BATTELLE AURAL READING DEVICE

The Battelle reading instrument is a direct translating, nonintegrating device utilizing a vertical sampling of a printed letter from its left to its right side. The audible response is the output and it utilizes an optophone type of output in that this instrument employs discrete sounds of various frequencies to indicate the relative position

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[13] *Ibid.*

of letter contours as the reading probe moves across the printed material. This particular device consists of two primary units. The first unit is the reading probe which has rollers for easy moving across the printed page and a housing wherein are located lamps, lens, a linear array of photocells, and a mechanism for adjusting the probe for various sizes of print. The second unit contains the electronics of the device, the controls, oscillators, switching circuits, a mixer, and an amplifier.[14]

The input of the Battelle device is the same as the other conventional reading devices for the visually handicapped-printed material. While using this particular device, the reading probe may be hand-held or placed into a mechanical tracker and moved in directional attack or a left-to-right sequence in much the same way in which a person with normal sight would read. While moving the reading probe from left to right, the contours of the letters react upon the photocells and the reader hears a tone pattern that is characteristic of the letter. This same procedure can be used for entire words, and the reader hears a tone pattern characteristic of that particular word. Consequently, by learning tone patterns for letters or words, the reader is able to distinguish or read printed material.[15]

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[14] Ibid., pp. 347-349.

[15] Ibid., p. 349.

The first five readers built were designated as Model A readers. They were operated by three controls. One control was the on/off control; another switch controlled the volume of the output and the last was for controlling a rheostat that adjusted the intensity level of the lamps located in the probe. These readers have eleven photocells, and the range in frequency in the output was from four hundred to four thousand cps with equal log separation.[16]

Experimentation with the Model A readers necessitated some alterations, which, according to Coffey, were:

1. An improved cable between the probe and the electronic components.
2. An improved filtering of the alternating current power supply.
3. The use of matched photocells and encapsulation of the entire array.
4. Detailed modifications to the audio oscillators and amplifier.
5. Improved rollers on the reading end of the probe.
6. Combining the on/off and volume controls.
7. A slight redesigning of the probe.
8. A more efficiently arranged packaging of the device.[17]

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[16] *Ibid.*

[17] *Ibid.*

After these alterations were made, three of the devices were called Model B readers.[18]

Later, a Model C. was constructed with many major improvements over the Model A and Model B readers. The reading probe was redesigned. The arrangement of the photocells was an important improvement. Additional lamps were placed in the reading head to decrease the sensitivity problem involved in the differential drifting of the photocells. Improvements also were made in the switching circuity and amplifier.[19] The machine has not been made public as of this date, however.

The training procedure. Early in the research program the first of a series of training programs was initiated. The majority of organized training activity was conducted at the Ohio State School for the Blind in Columbus. Other limited training has been given at the homes of several blind persons.

The first three years of training emphasized the letter as the unit of instruction. During that time, primary emphasis was put upon learning the auditory coded representations of the lower-case alphabet, the upper-case alphabet, and the nine numerals.

The philosophy of the letter training procedures was that if students could learn to identify the majority of printed English symbols absolutely, they would then be able to identify any word.[20]

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[18] *Ibid.*

[19] *Ibid.*

[20] *Ibid.*, p. 355.

Students from the beginning, were given training emphasizing letters; they were also reinforced for their ability to tell the differences among letters. In other words, the majority of the training procedures emphasized letters; therefore, their emphasis in was also on letters or on identifying all letters in a word, it may be that the training procedures reinforced behavior that was not particularly desired in the reading situation.

These procedures generally produced average reading rates of about three to four words per minute after sixty-five to seventy hours of training. The reading rates were measured on third- or fourth-grade level basic readers. With an additional one hundred hours of training, some of the better students were reading at rates from six to ten words per minute. The level of the test material was also somewhat higher. All of these results were based upon manual tracking by the subjects.

Throughout the training program, emphasis is placed on tracking words as units and on moving as rapidly and steadily as possible. The use of context in the reading situation with a minimum of retracking is encouraged. The specific goals of the program are to teach practical reading procedures and to bring average reading performance to a level of from 15 to 20 words per minute on approximately eighth grade level reading material in two hundred lessons of about one hour each.[21]

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[21] Ibid., p. 357.

Some other factors should be mentioned in connection with the experience of the Battelle Reader. The best reading rate recorded with the reading device was 37 words per minute, using the spring powered, hydraulically damped tracking device. This speed is almost double the speed which the same user was able to achieve using manual tracking.

Other research conducted along with that of the development of training procedures has been directed to the study of selection techinques. Work progressed toward developing simple tests involving the reader with a certain level of predictive power in selecting students for training with the device. These tests combined with subjective information that may be used to assist in selecting students should provide a guide for selecting those with the best chances for success with the device.

A number of training procedures using the Battelle device have not been explored. A great deal of judgment has had to be employed in selecting procedures because of the length of training required before the effects of the manipulation of any one variable. could be measured. It would have been interesting to test other approaches, but the time required has not been available. The objectives of the present training program are viewed as realistic, but do not represent the final word as to what is best. With additional experience it is entirely possible that more rapid reading rates will be achieved.[22]

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[22]Ibid., p. 359.

Future plans. Plans for the future include an evaluation of the Battelle Model D readers, and an evaluation of the training program by an independent organization. These evaluation programs are desired by both Battelle and the Veterans Administration to establish data that are independent of the original organization that conducted the development and evaluation.

The combined results of independent evaluations and those of Battelle will be major factors in any decision by the Veterans Administration regarding the future of the reader. Battelle is confident that with the improved Model D readers, and with close adherence to the completed training program, the results already obtained will be equaled and, hopefully surpassed.[22]

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[23] _Ibid._, p. 358.

CHAPTER III

THE AUDIO TRANSLATOR

Providing subject matter in readable form for the blind has been a problem. Braille systems and various optical and electronic devices have been available, however various disadvantages have been encountered in providing readable subject matter. Special publications, including the raised-letter Braille subject matter, are costly and unconventional, while various prior art devices for use in reading conventional typewritten subject matter have been unable to distinguish properly various letters one from the other in a sufficiently distinct audible manner to enable the blind readily to learn to read such subject matter from audible responses. To grasp an understanding of the immediate and future possibilities of the audioscope, the investigator offers a brief interpretation of the mechanics of the instrument and its operation.

I. PHYSICAL DESCRIPTION

Description of the translator. The audioscope, invented by the investigator, has the following characteristics: The instrument is portable, small in size, light in weight, and easy to carry and use in the reading process. The hand piece has an overall length of four inches. The scanning head is a rectangle one-half inch by one-sixteenth of an inch The barrel of the hand piece has a diameter of three-fourths of an inch.

The overall weight of the unit is two ounces, approximately. Therefore, the device can be held by the operator for long periods of time without fatigue.

Within the hand piece, is a small medical type three-volt lamp used to illuminate the material scanned through one-half of the rectangle of the scanning head. Figure 1, gives a cross-section of the components of the audioscope's scanning head. Viewing the illuminated area through the confines of the remaining half of the rectangle are two photo resistors or photo diodes. Each of these photo diodes receives reflected light from the scanned area through one-half of the remaining reading rectangle. These photo diodes are placed in light shields so that they are not affected by the light other than that received from the assigned sections or area. This is shown in Figure 1.

It is not the purpose of this study to describe the electronics involved in tone generators in great detail. Figure 2, page 30, shows the physical configuration of the tone generators used, and the Appendix shows the electrical diagram of the complete unit. Figure 3, page 32, shows the source of energy that is supplied to the illuminated lamp.

Each photo diode is electrically connected by means of a small, flexible multi-conductor cable to its respective direct current voltage amplifier as shown in Figure 4, page 34. These amplifiers in turn control voltage-sensitive frequency oscillators incorporating tunnel diodes, the frequency of each oscillator being a function of the

FIGURE 1

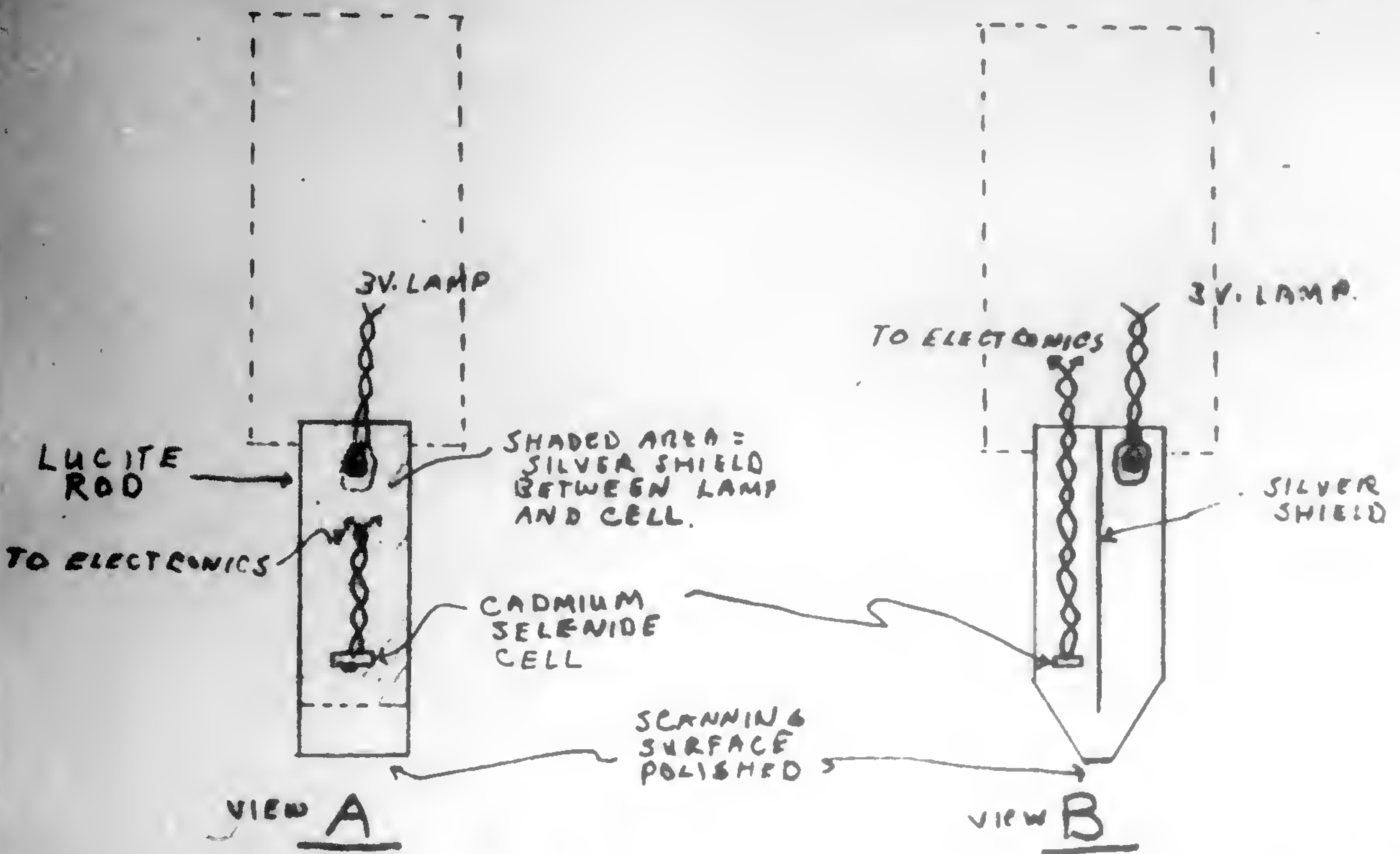
PHOTOGRAPH SHOWING CROSS SECTION OF THE COMPONENTS OF THE SCANNING HEAD OF THE AUDIOSCOPE

TITLE	CONT ON SHEET	SH NO
PROBE, READ	F	1
FIRST MADE FOR SOUND READER.		

CONT ON SHEET   SH NO.

28

REVISIONS



PROBE LUCITE ROD
OPAQUE BLACK ON
OUTSIDE.

CELL - CADMIUM SELENIDE
PEAK 3900 ANGSTROMS
LIGHT TO DARK RATIO 1000:1

DIMENSIONS OF PROBE
DEPEND ON SIZE OF
CHARACTERS TO BE
SCANNED

PROPORTIONAL PLACEMENT
OF COMPONENTS MUST BE
MAINTAINED

PRINTS TO

MADE BY	APPROVALS		DIV OR DEPT.		
TOM THORPE					
ISSUED MAR. 18, 1962	TT		LOCATION	CONT ON SHEET F	SH NO 1

FIGURE 2

PHOTOGRAPH SHOWING PHYSICAL CONFIGURATION OF THE TONE GENERATORS USED IN THE AUDIOSCOPE

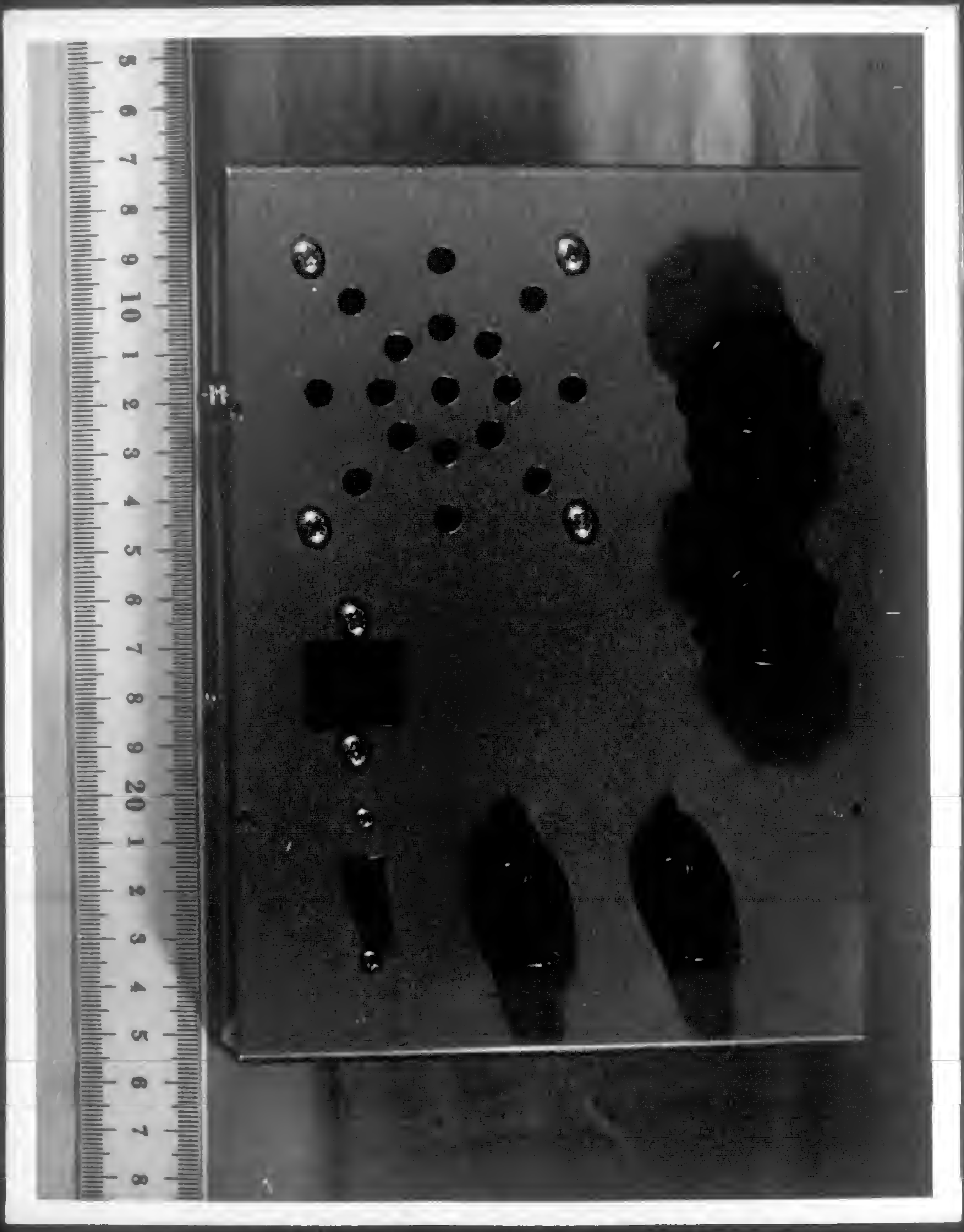


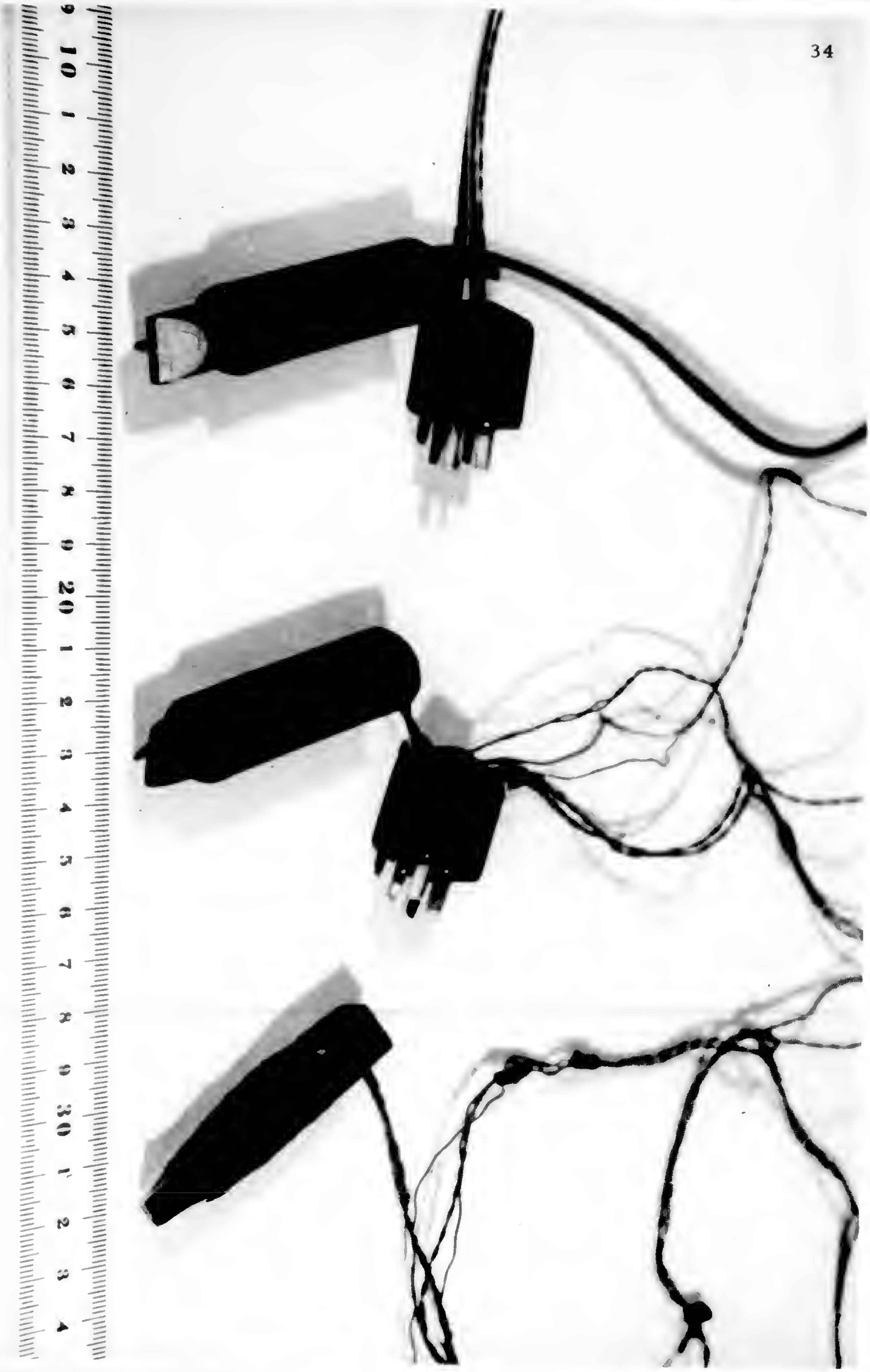
FIGURE 3

PHOTOGRAPH SHOWING SOURCE OF ENERGY SUPPLYING THE ILLUMINATED LAMP


9 20 1 2 3 4 5 6 7 8 9 30 1 2 3 4 5 6 7 8 9

FIGURE 4

PHOTOGRAPH SHOWING THE PROBES
AND FLEXIBLE CABLES



black-white ratio of its respective photo diodes. The audio frequency output of each tunnel diode oscillator is amplified by separate audio frequency amplifiers as shown in Figure 5, page 37. These amplified, isolated audio outputs are mixed and used to activate the final output amplifier. Provision is made for the volume of each output to be separately controlled.

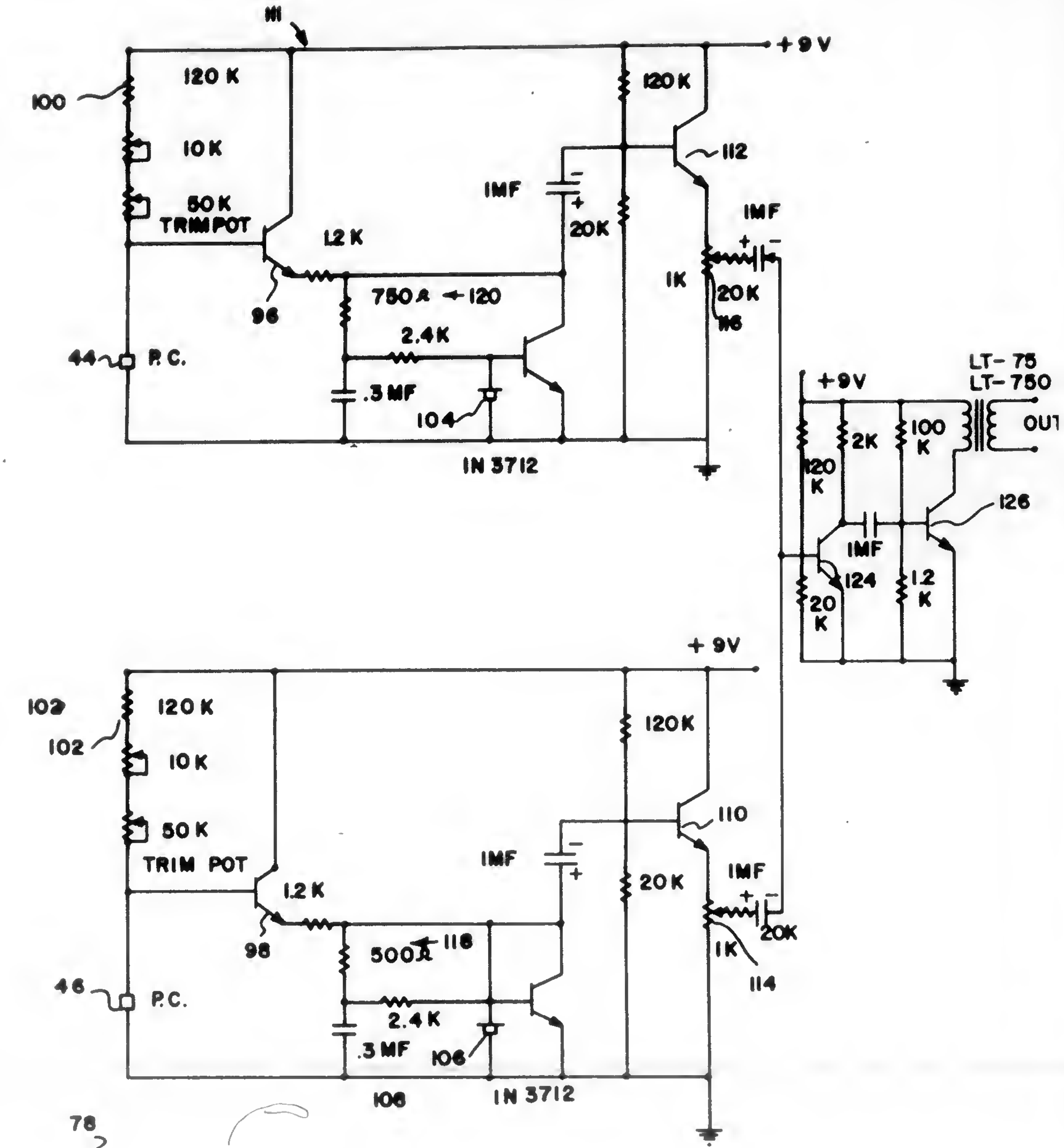
II. OPERATION OF THE INSTRUMENT

Operation of the audioscope. Each of the twenty-six letters and ten numerals is divided into vertical sections or areas. The upper and lower sections of each letter is converted into a sound which changes pitch at a different rate based on the black-white ratio of the letter area as shown in Figure 6, page 39. The upper section changes pitch faster than the lower section or area of the letter as shown in Figure 6, page 39. Consequently, the horizontal bar of the letter "T" will have a different pitch or tone than the horizontal bar of the letter "U". The bar of the letter "H" being sounded by both the upper and lower units at the same interval of time, produces still another set of sounds different from either the bar in the letter "T", or the letter "U". All horizontal bars in a given section sound consistently as one of three sound combinations for a given style of print.

Lines or bars at right angles to the direction of reading will produce a complexity of sounds resulting from the treble audio-

FIGURE 5

PHOTOGRAPH SHOWING AUDIO FREQUENCY AMPLIFIERS
FOR EACH TUNNEL DIODE


111
+9V
100
120 K
10 K
50 K
TRIMPOT
120K
112
IMF
20K
1.2 K
IMF
750Ω 120
1K
20K
116
96
2.4K
44 P.C.
.3MF
104
IN 3712
LT-75
LT-750
+9V
2K
100 K
OUT
120 K
126
IMF
124
20 K
1.2 K
+9V
102
102
120K
10K
50K
TRIM POT
120K
110
IMF
20K
IMF
1.2K
20K
98
500Ω 118
1K
114
46 P.C.
2.4K
.3MF
106
106
IN 3712

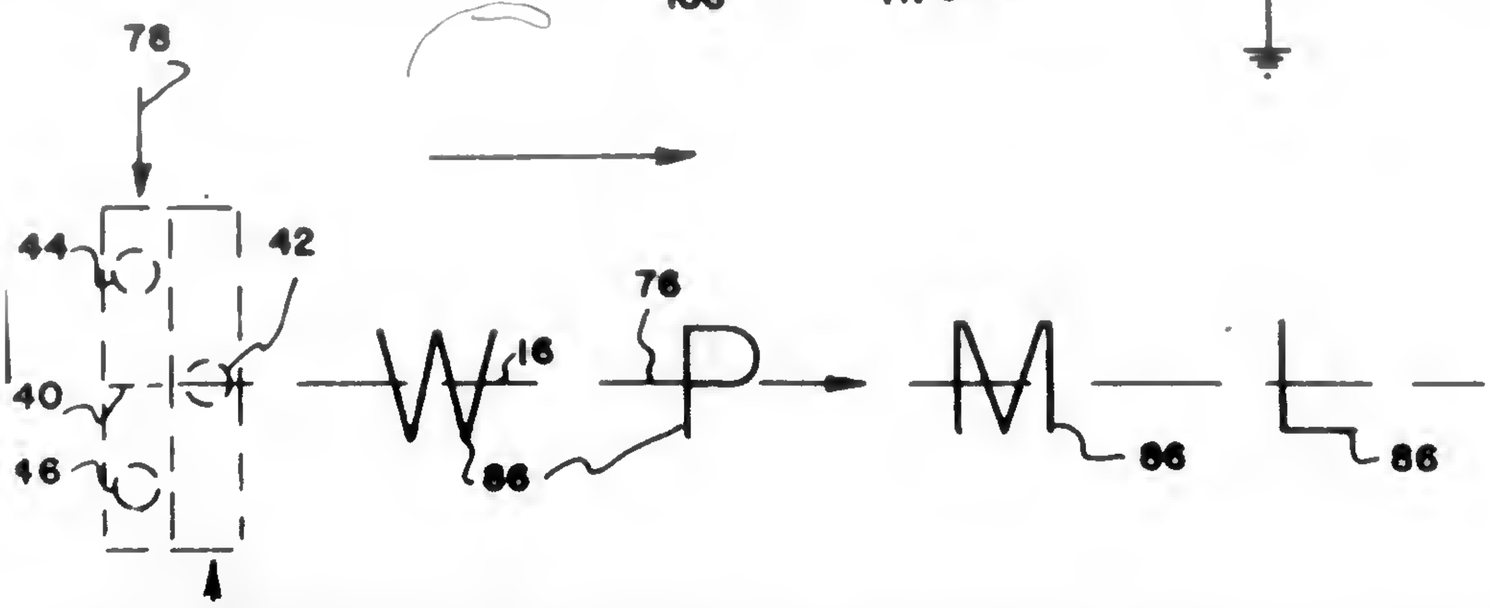
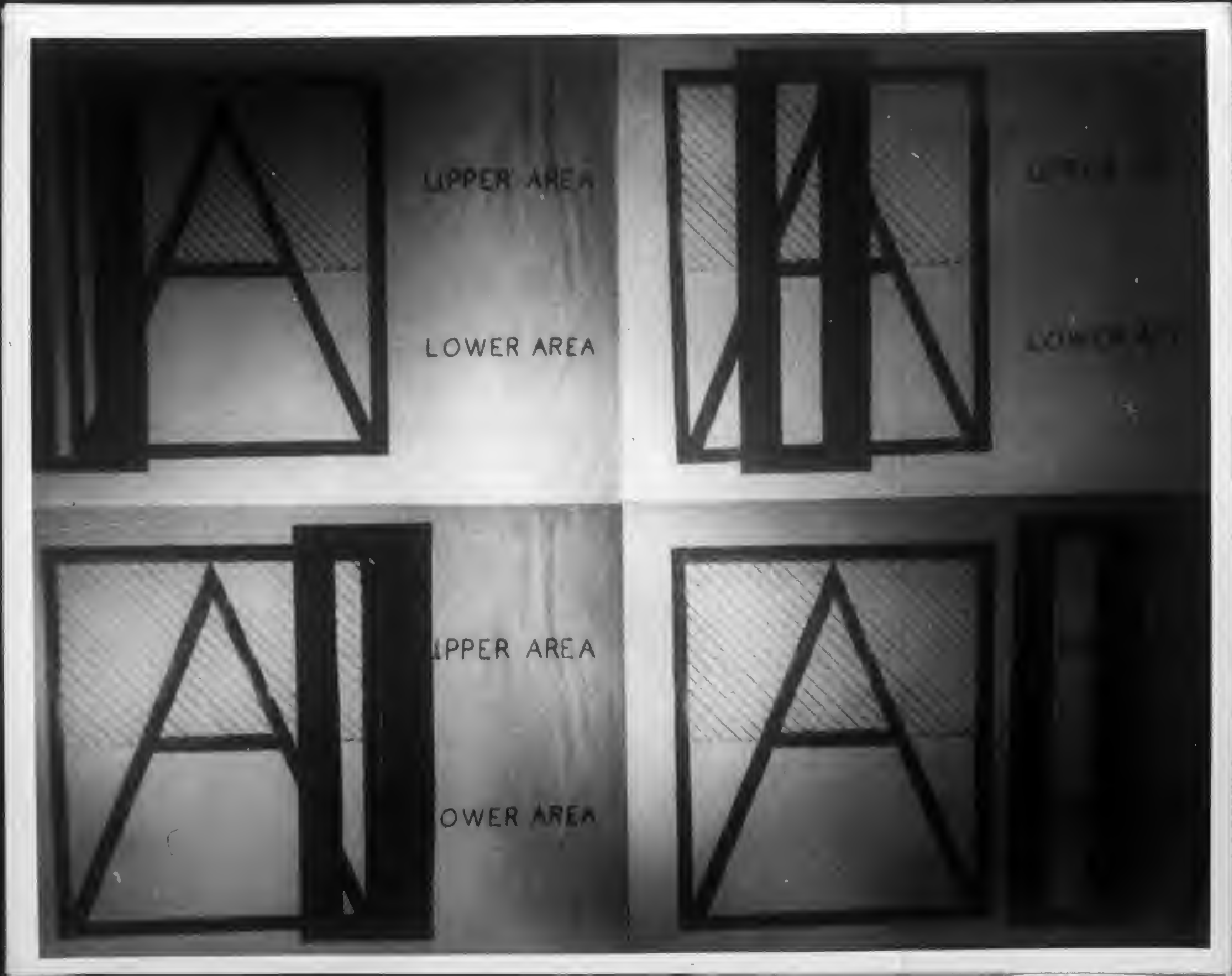

78
44
42
76
40
16
46
86
86
86

FIGURE 6

PHOTOGRAPH SHOWING BLACK-WHITE AREA RATIOS


UPPER AREA
LOWER AREA
UPPER AREA
OWER AREA

range of the unit or oscillator assigned to the upper section or letter area. These frequencies then are channeled to an electronic mixer with those from the treble audio-range of the lower section oscillator, the resultant sound being assigned at all vertical bars extending through both sections or letter areas.

Lines or bars at angles other than ninety degrees will produce sounds dependent upon their total length and slope. The leading left edge of the letter "V" will produce a sound different from the inverted "v". In the "V", the upper section is activated first, the pitch being a function of its black-white ratio as the letter is scanned. The inverted symbol first activates the lower section or area; consequently, the oscillator first produces a different set of sounds. By utilizing dual non-linear oscillators, each letter or numeral is assigned a different set of sounds based on its geometric size and shape. If only one oscillator were used, letters such as "H" and "U" would have the same sound. A single oscillator could not differentiate the relative position of the horizontal bar.

In operating the audioscope, the operator places the reading head in physical contact with the printed material that is to be scanned, with the machine being first energized by a self-contained power supply. The starting bias of each unit is adjusted to give a constant response or tone on a white paper as shown in Figure 7, page 42. This response can be null on white paper or a constant bass tone or tones at the discretion of the operator. The paper is then explored

FIGURE 7

PHOTOGRAPH SHOWING ACTUAL OPERATION

OF THE AUDIOSCOPE


Experimenti

by the hand piece and the starting area located. The reading head is drawn across the material from left to right in the normal reading manner, the rate of scanning being controlled by the operator. Should the reading head not be held normal to the line of print, or should it wander off during reading, the tones will change and the operator can retrace his scanning path and correct the error of horizontal left to right sequence. Each word can be retraced as often as required until the meaning is understood. The line position can be determined in the same manner as that in which the index finger is used in the Braille system to assure the correct reading line.

CHAPTER IV

PROCEDURES

Very limited reference has been noted in the related literature pertaining to procedures for instructional purposes using this medium as a method of reading print, consequently, the investigator, before embarking upon the final effective procedure, experimented with visually handicapped pupils to find what appeared to be the most efficient method of introducing and exposing students to a relatively new concept of reading the printed page. Four distinct phases were identified in the instruction period.

Phase One. This investigation was concerned with partially sighted and totally blind students in the technique of identifying marks or indicia on paper and the eventual interpretation of these marks as a method of communication. The students first were introduced to the audioscope by means of a demonstration by the instructor.

Each of the four controls on the instrument was explained to each student, and the control positions identified by touch. For example, the oscillator bias control which sets a threshold of response was adjusted to give a null response on white paper and a resulting high pitch audio-response on solid black paper. The student's hand then was placed on the controls and allowed to adjust the controls throughout the full range. The instructor explained the purpose of the controls as being one of a starting position. It was demonstrated that when the instrument is used, it may be necessary from time to time, to reset the bias control because the paper

may change in quality, or extraneous foreign matter such as dust or dirt may be a part of the material, and, consequently, would produce sound. The student was reminded constantly of the fact that anything that affects light would be converted to sound, and that if a sighted person can see markings on white paper in the form of dust or dirt, then a sightless person will hear these same marks. After the student gained some proficiency in adjusting the position to a null response, the use of the volume control for this particular oscillator--Oscillator A was explained. The student was permitted to run the volume control through its entire range in order to find a volume suitable and pleasant to his particular hearing.

After adequate mastery of this phase of instruction, the instructor, in a similar manner, explained the use of the second oscillator. This oscillator was adjusted to the null position and the student was permitted to practice this operation at the same time varying the audio volume by means of the control for this oscillator.

Instruction was given in the use of the earphone and the loud speaker. The loud speaker was used for instructional purposes and the earphones for private listening. Prior to the adjustment of the oscillators, instruction was given regarding the location of the "on" and "off" switch and the correct method of using this switch in assuring adequate performance of the instrument. Students received ten minutes instruction on the method of adjusting the machine. At the end of this period, they were proficient in manipulating all the controls and obtaining a null response

on a white background. Hence, the students were confident in the use of the volume control for each oscillator and were able to turn the machine on and off to readjust the controls at the request of the instructor.

Phase Two. The second phase of instruction permitted the students to hear the difference between white paper and black marks. This was accomplished by making a series of vertical lines three-eighths of an inch in height horizontally spaced across a white sheet of paper. The lines were spaced at regular intervals of one inch and were ten in number in the first line. The students were given an explanation as to what to expect and were allowed to listen to the sound of a given mark when the instructor moved the probe across the first, second, and third and fourth marks.

The students then were given the probe, with instructions to explore the paper and to locate the line containing the marks. The edge of the paper was found by feeling, and the students moved the probe across the paper in a rather random fashion until the first mark was found. The students were aware that the vertical marks were arranged horizontally as they moved the probe slowly to the right until the second mark was found. At this point the instructor moved the probe vertically off this mark, explaining that there would be a tone change which would indicate that the probe was not moving in a straight line. Also, when the probe was moving in a straight line, a given sound was heard when a mark was located, and when the probe was not perfectly centered over the mark another sound was produced. Utilizing this method, the students were instructed to move the probe in a horizontal line. This required

approximately thirty minutes of training time in order to move the probe horizontally in a straight line without error. At the end of the line the students were asked for the number of marks.

Next, additional sheets of paper were produced with marks running from ten to twenty in a random fashion and with lines spaced approximately one inch apart. The student was permitted to explore the paper and at the end of each line was instructed to indicate the number of marks that were found. On the first few attempts the probe was not moved horizontally and there was confusion as to when a row had been left out. However, after an explanation by the instructor pertaining to the change in sound when the mark was not perfectly centered on the probe, the students were able to accomplish the second phase of training, consisting of the identification of vertical marks and was able to respond regarding the number in each row. Total training time for this phase was two sessions of forty-five minutes each.

Phase Three. In the third phase of identification, the marks were placed horizontally on the white paper. At this point, the student endeavored to produce three separate tones by moving the probe in a horizontal position. This was a very important learning exercise because when the probe is moved so that the marks are positioned in the center of the probe, both oscillators respond. When the probe is moved so that the mark is positioned in the upper oscillator section, only the upper oscillator responds, and the sound is that of a single oscillator, which is different from that of both oscillators when the probe is moved to the center position. The same process was repeated using the lower part of the

probe or the lower area or section oscillator. Here the instrument produced a sound differing in pitch and quality from either of the first two sounds obtained.

The instructor asked the students after the first mark identifying the beginning of a row was properly found, as to whether the student was obtaining sound produced by both oscillators or by an oscillator representing a single area. This instruction was given in order to gain proficiency of identification and use of the various areas. The length of time of this instruction consisted of three forty-five minute sessions.

Phase Four. The fourth phase involved vertical, horizontal, and slanted markings. These marks also were three-eighths of an inch in height and were one-sixteenth of an inch in width. They were spaced one inch apart. Instruction time for this exercise, consisting of one sheet of paper and fifty responses, was forty-five minutes at the end of this period a review of former exercises was discussed with the students.

The vertical marks and their particular sounds then were related by the instructor to the selected letters having vertical lines, namely: "D," "E," "F," "H," "I," "N," "T," "U," and "Y".

In a similar manner horizontal marks and their particular sounds were related to letters having horizontal lines, namely: "A," "E," "F," "H," "T," and "U".

The constant changing pitch of slanted lines was related to letters having slanted lines, namely: "A," "N," and "Y".

Similarly, the subtle, varying sounds of curved letters were related to their shape, namely: "D", and "O".

In order to illustrate the sound-shape relationship of the letters selected, these letters were cut out of heavy cardboard and were approximately three inches in height. The students were asked to feel them as they listened to the "letters shape" drawn by the probe in sound, operated by the instructor.

This tactile-audio letter relationship gave the students an operating sound vocabulary of the selected letters. The students were able to picture the graphic representation of these letters from the audio responses. The graphic representation of the letter "I" was obtained from the short response of both oscillators as the instrument moved across it. The letter "T" started with the horizontal bar energized the upper area's oscillator, and as the instrument was moved to the right, both upper and lower area's oscillators responded to the vertical stem of the letter "T".

Finally, as the instrument was moved further to the right, again only the upper area's oscillator responded. In a similar manner, the other letters were illustrated.

The students were then given an exercise consisting of these letters, "A, D, E, F, H, I, N, O, T, U, and Y," printed with black ink, three-eighths inch in height on white paper. A forty-five minute identification practice time was given to this exercise.

The selected words composed of the previously identified letters

were those found to be the ten most commonly used words in the English language by the Bell Telephone Laboratory, namely: I, THE, A, IT, TO, YOU, OF, AND, IN, AND HE. After identification of the selected letters was accomplished, the students were able in two instruction periods of forty-five minutes each to identify these words as word sounds rather than as individual letters.

Appendix A, page 56 of this study contains selected individual records of each student participating in the study.

The individuals selected to participate in the study were classified as academically highly endowed.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

An objective of this investigation was to develop and perfect a small, compact electronic audible response device to assist visually handicapped people in reading printed characters and to formulate a method of teaching this audio-language of the printed characters to a sampling of visually handicapped elementary school children.

The study was limited to teaching the visually handicapped the letters in the upper case, three-eighths of one inch in height printed with black printers ink on a white surface. These letter combinations made up the ten most frequently used words in the English language.

Review of the literature. An exhaustive review of the literature failed to yield a great deal of information relevant to the type of translation used by the investigator. A professional patent search conducted by a Patent Attorney, and the resultant patent application is included in Appendix B, page 60 of this study.

Audio-scope. An audio-scope designed especially for this investigation was used to translate the printed materials into their audio-responses. This device is explained in Chapter III, page 25.

Procedures. Selected visually handicapped children were taught the meaning of these audio-responses by relating them to the tactile shape of the letters and words used in this study.

I. CONCLUSIONS

The objectives of the problem were to test the hypothesis that children can be taught to interpret audio-responses electro-optically converted from letters into language. Based on the findings of this investigation, the following were concluded:

1. The tactile shape of letters and words can be related to audio-responses.
2. Visually handicapped children can interpret audio-responses translated from printed materials as limited in this investigation into language.

II. RECOMMENDATIONS

As a result of this study, the investigator recommends the following be investigated in future investigations.

1. An investigation to determine the rate of learning Morse Code compared to the Audio-scope.
2. An investigation to determine the rate of learning selected audio-responses without the tactile letter relationship as described in Chapter I V, page 44.
3. An investigation to determine the relationship between hearing loss, age, Intelligence Quotient, and sex upon the rate of learning by means of the Audio-scope.
4. An investigation to teach basic geometry by using a similar device.
5. An investigation to teach astronomy by using a similar device.

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APPENDIX A

AUDITORY ACUITY RATINGS OF PARTICIPATING INDIVIDUALS

HEARING LEVEL IN DECIBELS

Frequency	125		250		500		750		1,000		1,500		2,000		3,000		4,000		6,000		8,000	
S	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
1	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
2	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
3	30	15	25	15	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
4	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
5	15	15	15	15	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15

VISUAL ACUITY AND CAUSE OF BLINDNESS*

S	Visual Acuity		Cause of Blindness
Code	Right Eye [	Left Eye	
1	Finger Counting	Light Perception	Congenital Familial Dysontonomia with corneal involvement
2	Total Loss	Total Loss	Glaucome and Retrolental Fibroplasia
3	Blind	Blind	Retrolental Fibroplasia
4	Light Perception	Total Loss	Retrolental Fibroplasia
5	Light Perception	Total Loss	Retrolental Fibroplasia

*As per opthalmological reports

AGE, SEX AND GRADE

SUBJECTS	SEX	AGE (Yr.)	GRADE
1	F	12.10	7
2	F	10.11	5
3	F	10.90	3
4	M	7.10	3
5	F	12.20	7

APPENDIX B

AUDIOSCOPE U.S. PATENT APPLICATION

APPENDIX B

This invention relates to a sonic reading device and, more particularly, to a sonic reading device for use by the blind for sonic recognition of conventional typewritten matter so that blind persons may be taught to read the usual typewritten matter conventional to those who have normal sight.

It has been a problem to provide subject matter in readable form for the blind. Braille systems and various optical and electronic devices have been provided, however, various disadvantages have been encountered in providing readable subject matter for the blind. Special publications, including the raised letter Braille subject matter, are costly and unconventional, while various prior art devices for use in reading conventional typewritten subject matter have been unable properly to distinguish various letters, one from the other, in a sufficiently distinct audible manner so that the blind may readily be taught to read such subject matter from sonic responses.

Accordingly, it is an object of the present invention to provide a sonic reading device which is very small and compact and which provides very distinct sonic responses to value conditions ranging from black to white and to various colors so that letters or other indicia printed on conventional paper or other subject matter may be readily distinguished sonically by widely divergent tones produced by the sonic device of the invention in response to various portions of typewritten characters.

Another object of the invention is to provide a very simple sonic reading device in which a light source projects light directly onto subject matter being read, said light passing through the tip of the probe assembly of the invention and reflected directly from the typewritten subject matter back into the device whereupon it is sensed by a photo diode having circuitry coupled thereto and responsive to create a wide range of tone frequencies extending from white to black so that a wide range of frequency discrimination may be obtained to recognize various letters or indicia printed on a piece of paper or other material.

Another object of the invention is to provide a sonic reading device having a probe movable over typewritten subject matter; said probe having a window of light transmitting material disposed to be in contiguous relation with print or indicia, the window being disposed progressively to scan letters and being partitioned so that a light source in the probe casts light on the letters, and whereby the partition structure separates a pair of photo diodes which are

responsive to light received from the letters at their upper and lower portions respectively; said photo diodes each connected to separate oscillator circuitry and each disposed to provide a varying frequency gain in relation to a range of values from white to black so that the frequency change in sonic response to the upper and lower portions of letters or characters being read may vary sufficiently properly to distinguish differences between upper and lower portions of the letters and thereby provide very distinctive responses to certain subject matter.

Another object of the invention is to provide a sonic reading device having a very novel reading probe structure operable in contiguous relationship to printed or other indicia subject matter; said probe being provided with light sensitive elements and a light source; said light sensitive elements and said light source separated by an opaque partition and both communicating with a common reading window whereby the light source casts light upon the subject matter being read and the light is reflected from the subject matter to the opposite side of the partition whereat the light sensitive devices sense the character pattern of the light and control oscillator circuits which generates distinctive tones which identify the indicia or typewritten subject matter.

Another object of the invention is to provide a sonic reading device having a very simple and novel means for distinguishing sonically the form characteristics of various indicia or typewritten subject matter conventional to the use of those having normal sight whereby blind may readily be taught to read almost all conventional printed matter.

Another object of the invention is to provide a sonic reading device having novel means adapted to permit or assist the blind to sonically recognize various colors.

Other objects and advantages of the invention may be apparent from the following specification, appended claims and accompanying drawings, in which:

Figure 1 is a side elevational view of a sonic reading device in accordance with the present invention and showing an earphone and conventional speaker which may be used alternative to each other in connection with the device;

Figure 2 is an enlarged sectional view taken from the line 2-2 of Figure 1;

Figure 3 is a sectional view taken from the line 3-3 of Figure 2;

Figure 4 is an end view of the probe taken from the line 4-4 of Figure 3 showing the light transmitting receiving window of the invention;

Figure 5 is a sectional view taken from the line 5-5 of Figure 3;

Figure 6 is a sectional view taken from the line 6-6 of Figure 3;

Figure 7 is a graphic illustration of tone frequency ranging from the silent portion of the audio range to 4,000 cycles or more, and responsive respectively from white to black values and illustrating varying frequency responses of separate oscillators tuned to provide sonic distinctions between upper and lower portions of letters of typewritten subject matter or other indicia; and

Figure 8 is a diagrammatic view of the electronic circuitry of the invention.

As shown in Figure 1 of the drawing, a probe assembly 10 is provided with a light transmitting and receiving and 12 disposed to be operated adjacent a surface 14 of a piece of paper or other material upon which printed matter is disposed. The reader, in order to progressively read letters on the surface 14, moves the probe in the direction of an arrow 16, as shown in Figure 1 of the drawings. The probe 10 is provided with a casing 18 which may be provided with self contained batteries and electronics equipment to be hereinafter described, and electrically coupled by conductors 20 is an earphone 22 which may be utilized by a blind person without distrubing those surrounding him, thus the blind person may sonically recognize indicia on the surface 14 in a secluded manner.

It may be desirable to utilize a speaker 24 in connection with the circuitry contained in the casing 18, and, accordingly, conductors 26 may be utilized in place of the conductors 20 and coupled to the circuitry in connection with the casing 18 by a conventional removable plug 28.

As shown in Figure 2 of the drawings, the probe assembly 10 is provided with a light transmitting and receiving casing 30. This casing 30, as shown in Figure 2 of the drawings, may be rectangular in cross section or may be circular in cross section, if desired. The casing 30 is provided with an outermost opaque layer 32, which may either be black paint or a metallic or other opaque enclosure wherein lucite sections 33, 34, and 36 are contained. These sections are separated by a main partition 38. This partition 38 separates the light transmitting sections 33 from the sections 34 and 36, and

these sections 34 and 36 are separated from each other by a partition 40.

Referring to Figures 3 and 5 of the drawings, it will be seen that the section of light transmitting material designated 33 contains a lamp 42 which serves as a light source for the device, as will be hereinafter described in detail. In the light transmitting sections 34 and 36 are contained a pair of light sensitive elements 44 and 46. Near the lower end of the casing 32 the walls thereof are provided with converging portions 48 and 50, and the light transmitting sections 33, 34 and 36 are integral at 52 below a lower edge 54 of the partition 38. Thus, these light transmitting sections may be of lucite or other light transmitting material so that light transmitted by the lamp 42 may be case on the surface 14, as hereinbefore described, and reflected back upwardly into the light transmitting portions 34 and 36 to the light sensitive elements 44 and 46, which are preferably photo diodes or other equivalent devices. It will be seen that lower edges 56 and 58 of the casing 32 are spaced apart so that the light transmitting material 52 is in the form of an elongated window, as shown in Figure 4 of the drawings.

The casing 32 is provided with a slot 60 in one side thereof, and this slot extends through the light transmitting material 34 and 36 to receive a color filter slide 62 having a blue section 64 and a red section 66. These sections are separated by a slotted portion 68 which straddles the partition 40. Thus, the light sensitive element 44 may be affected by the blue filter 64 and the light sensitive element 46 may be affected by the red filter 66.

Coupled to the lamp 42 are conductors 70, and coupled to each of the light sensitive elements 44 and 46 are conductors 72 which extend upwardly into the casing 18 and which are connected to electronic circuitry which will be hereinafter described in detail.

As shown in Figure 3 of the drawings, it will be seen that a lower edge 74 of the partition 40 is located substantially on a common level with the lower edge 54 of the partition 38. Thus, light transmitted downwardly through the light transmitting material 33 from the lamp 42 is reflected from indicia on the surface 14 and this light passes upwardly as reflected from the surface 14 through the material 34 and 36 at opposite sides of the partition 40 and to the light sensitive elements 44 and 46. The partition 40, as shown in Figure 9 of the drawings, is disposed to be operated along a median line designated 76, which tends bifurcate areas of typewritten material into upper and lower sections. Sonically it is very simple to center upper and lower ends 78 and 80 of the probe reading window and then the partition 40 separates the light received by the light sensitive elements 44 and 46 with respect to upper and lower portions of letters of typewritten material shown in Figure 9. Accordingly, the light source 42

eliminates the letters progressively as the probe is moved in the direction of the arrow 16, and the light sensitive elements 44 and 46 individually respond to upper and lower portions respectively of the characters, whereby frequency generating circuits individually controlled by the light sensitive elements 44 and 46 emit tones beginning at the lower end of the audio range, the tones varying in frequency relative to the light sensitive elements 44 and 46 so that distinct sonic differences may be recognized between upper and lower portions of the typewritten letters shown in Figure 9, said upper and lower portions being above and below the broken line 76.

With reference to Figure 7 of the drawings, it will be seen that one of the light sensitive elements 44 or 46 controls an oscillator to generate a tone which may vary along a line 82 gaining very rapidly in frequency from a white to black condition reflected to the respective light sensitive element. The other light sensitive element 44 or 46 controls an oscillator which generates a tone represented and variable along a line 84, shown in Figure 7. This tone will have a frequency increase which is substantially less than the line 82 with respect to a white or black condition reflected to the respective light sensitive element. Thus upper and lower portions of the letters designated 86 in Figure 9 of the drawings may readily be distinguished by varying frequencies emitted from oscillators controlled by the light sensitive elements 44 and 46, as for example, the letters "p" and "l" are very easily distinguishable since the lower portion of the letter, such as the letter "l" may be distinguished at a different frequency than the upper portion of the letter "p".

Considering the letter "m" it will be seen that varying frequencies generated for the upper and lower portions of these letters may readily render them sonically distrinct. This is also true of the letter "w".

It will be apparent to those skilled in the art that the horizontal or longitudinal movement of the probe window in a direction of the arrow 16 provides the operator with very distinctive tones varying in response to longitudinal movement of the probe over a line of indicia or typewritten material.

It will be understood that the foregoing operation related to direct reading of black and white subject matter is ordinarily carried on with the filter 62 removed and with a blank member similar to the member 62 filling the slot 60 but having transparent sections used in lieu of the sections 64 and 66. Thus, the normal operation of the reading probe, hereinbefore described, may be obtained without the filter 62.

When the filter 62 is used, the red and blue filter elements 64 and 66 receive light reflected from a colored object and both receive the same light, but due to the combinations of light filtered by these red and blue filters and received by the light sensitive elements 44 and 46 a composite tone will be generated by the separate oscillators coupled thereto, and this composite tone will be readily distinguishable as a color value from a sonic standpoint. Thus, for normal black and white reading, the color filter is removed and a blank is placed therein to close the slot 60, and for ordinary color recognition the color filter 62 is used and the projecting tab portion of this filter 62 is provided with an opening 88 or other distinguishing mechanical feature to assist the blind in properly orienting this filter so that the blue and red elements are in the same relation to the light seneitive elements 44 and 46. Also, such orientation may be attained by reference to a projection 90 on the housing 18, such projection 90 being usable as a control switch or other device.

Reference is now made to the diagrammatic illustration of the electronics equipment of the invention as shown in Figure 8 of the drawings.

This circuitry comprises a pair of oscillator sections 108 and 111. Each section is similar to the other with exception that the section 108 has an output frequency slightly higher than section 111.

The hereinbefore mentioned light sensitive elements 44 and 46 are disposed in the oscillator sections 111 and 108, respectively. These light sensitive elements 44 and 46 may be any suitable light sensitive transducers such as a photo resister or photo diode, and they control the respective single voltage amplifiers 111 and 108 wherein these light sensitive elements are coupled to respective transistors 96 and 98. Each amplifier section employs a 120K resistor in series with two potentiometers having values at 10k and 50k. Each 50k potentiometer being preferably a trim pot requiring factory adjustment. These resistors are connected to respective base portions of the transistors 96 and 98. The photo resistors 44 and 46 bridge a connection between the base of the respective transistors and ground. Any variation of light sensed by the photo resistors will be reflected as an ohmage change in the respective resistive network of the circuitry sections 111 and 108.

The 10k potentiometer in each circuit section is used to set the initial threshold of each respective voltage amplifier. The output of these voltage amplifiers are coupled to respective voltage sensitive oscillators consisting of tunnel diodes 104 and 106 arranged in oscillating circuits.

The frequency range of this circuitry is now a function of the light condition of the photo diodes 44 and 46, and the slope of the curve representing the audio output of this oscillator circuitry is controlled by a RC network consisting of the oscillator section 108 wherein a 500 ohm resistor and a .3 mfd capacitor is employed to provide for operation at a relatively higher frequency than that of the circuitry section 111.

The output of the sections 108 and 111 are amplified by means of transistors 110 and 112, thereby providing transistor amplifiers.

Provisions are made at this point for volume selection by means of a 1k potentiometer isolated from the other oscillator circuit by a 20k resistor and capacitably coupled by a 1 mfd. capacitor. Thus, each section 108 and 111 is equipped.

The oscillator section 111 is of substantially identical construction to that of the oscillator section 108, however, variation of the RC network separates the two oscillators frequency-wise in that the section 108 employing the 500 ohm resistor 118 operates at a higher frequency than the section 111 wherein the 750 ohm 120 is disposed. Outputs from both sections 108 2nd 111 are mixed and capacitably coupled to a dual stage audio amplifier 122 consisting of two transistors 124 and 126.

The output of the final transistor is the transformer coupled to the desired reproducer in the form of either earphones 22 or the loudspeaker 24.

It will be seen, with reference to Figure 7 of the drawings, that the section 108 corresponds with the curve 82, hereinbefore described, and that the output from the section 111 corresponds with a relatively lower frequency as exemplified by the curve 84 in Figure 7. Thus, the audio responses of the probe above and below the line of 76 as shown in Figure 9 of the drawings are varied in frequency, and thus, enable the reader clearly to distinguish various letters, one from the other.

From the foregoing it will be obvious that the device of the present invention is very simple, easy to operate, and readily usable by the blind audibly to distinguish various characters from each other and readily to read them audibly from printed subject matter generally utilized by persons having normal sight.

It will be obvious to those skilled in the art that various modifications of the present invention may be resorted to in a manner limited only by a just interpretation of the following claims.

I claim:

1. In a sonic reading device the combination of: a reading probe housing having a scanning window at the normally lower extremity; a partition in said housing extending downwardly into close proximity with said window; a light source on one side of said partition; and a light sensitive element on the opposite side of said partition whereby light from said source may pass through said window to illuminate characters on a sheet or surface adjacent thereto so that said illuminated characters on said surface are sensed by said light sensitive element; and amplifying circuitry coupled to said light sensing element and responsive to degrees of black and white subject matter from which said light is reflected to generate varying frequency tones.

2. In a sonic reading device the combination of: a reading probe housing having a scanning window at the normally lower extremity; a partition in said housing extending downwardly into close proximity with said window; a light source on one side of said partition; and a light sensitive element on the opposite side of said partition whereby light from said source may pass through said window to illuminate characters on a sheet or surface adjacent thereto so that said illuminated characters on said surface are sensed by said light sensitive element; and amplifying circuitry coupled to said light sensing element and responsive to degrees of black and white subject matter from which said light is reflected to generate varying frequency tones; said window being elongated and of sufficient length to span the generally vertical dimensions of type or printed subject matter.

3. In a sonic reading device the combination of: a reading probe housing having a scanning window at the normally lower extremity; a partition in said housing extending downwardly into close proximity with said window; a light source on one side of said partition; and a light sensitive element on the opposite side of said partition whereby light from said source may pass through said window to illuminate characters on a sheet or surface adjacent thereto so that said illuminated characters on said surface are senses by said light sensitive element; and amplifying circuitry coupled to said light sensing element and responsive to degrees of black and white subject matter from which said light is reflected to generate varying frequency tones; said circuitry comprising a tunnel diode oscillator circuit and an amplifier.

4. In a sonic reading device the combination of: a housing having a window in its normally lower end; a first partition in said

housing; a light source on one side of said partition and communicating with said window; second partition means dividing the space in said housing at the opposite side of said first mentioned partition into a plurality of separate areas; a light sensitive means in each of said last mentioned areas and disposed to receive light from said window below said first mentioned partition, said light being reflected from a surface adjacent said window and provided by said light source; a plurality of oscillator circuits coupled to said light sensitive elements; each of said plurality of oscillators having means disposed to cause these oscillators to operate on different frequencies relative to each other; and means for amplifying the frequencies in an audio stage so that the operator of the device may pass said window along a line of type and distinguish upper and lower portions of the letters from each other by means of different audio frequencies provided for by the different frequencies at which said oscillator circuits operate.

5. In a sonic reading device the combination of: a housing having a window in its normally lower end; a first partition in said housing; a light source on one side of said partition and communicating with said window; second partition means dividing the space in said housing at the opposite side of said first mentioned partition into a plurality of separate areas; a light sensitive means in each of said last mentioned areas and disposed to receive light from said window below said first mentioned partition, said light being reflected from a surface adjacent said window and provided by said light source; a plurality of oscillator circuits coupled to said light sensitive elements; each of said plurality of oscillators having means disposed to cause these oscillators to operate on different frequencies relative to each other; and means for amplifying the frequencies in an audio stage so that the operator of the device may pass said window along a line of type and distinguish upper and lower portions of the letters from each other by means of different audio frequencies provided for by the different frequencies at which said oscillator circuits operate; red and blue filter means disposable in a pair of said areas at opposite sides of said second partition means and disposed to vary the light relative to the pair of said light sensitive elements to cause a composite variation in the frequency operation of said oscillators whereby variations in color may be audibly recognized.

6. In a sonic reading device the combination of: a reading probe housing having a scanning window at the normally lower extremity; a partition in said housing extending downwardly into close proximity with said window; a light source on one side of said partition; and a light sensitive element on the opposite side of said partition whereby light from said source may pass through said window to illuminate characters on a sheet or surface adjacent thereto so that said

illuminated characters on said surface are sensed by said light sensitive element; and amplifying circuitry coupled to said light sensing element and responsive to degrees of black and white subject matter from which said light is reflected to generate varying frequency tones; said probe housing having light transmitting material therein in which said light source and light sensitive element are embedded.

7. In a sonic reading device the combination of: a light source disposed to illuminate printed or other subject matter; a reading probe housing having a window therein disposed to receive light and adapted to be directed adjacent to illuminated printed matter; a partition in said housing separating it into a plurality of compartments; a light sensitive element in each of said compartments; oscillator circuitry coupled to each of said light sensitive elements; and means in each of said oscillator circuitry portions causing the oscillator circuitries respective to each light sensitive element to operate on different frequencies relative to each other.

8. In a sonic reading device the combination of: a light source disposed to illuminate printed or other subject matter; a reading probe housing having a window therein disposed to receive light and adapted to be directed adjacent to illuminated printed matter; a partition in said housing separating it into a plurality of compartments; a light sensitive element in each of said compartments; oscillator circuitry coupled to each of said light sensitive elements; and means in each of said oscillator circuitry portions causing the oscillator circuitries respective to each light sensitive element to operate on different frequencies relative to each other; and means comprising a dual stage audio output device coupled to said oscillators disposed to provide audible signals varying in frequency with respect to the individual light sensed by the respective individual light sensitive elements.

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A SONIC READING DEVICE

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January 1964

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Maricopa

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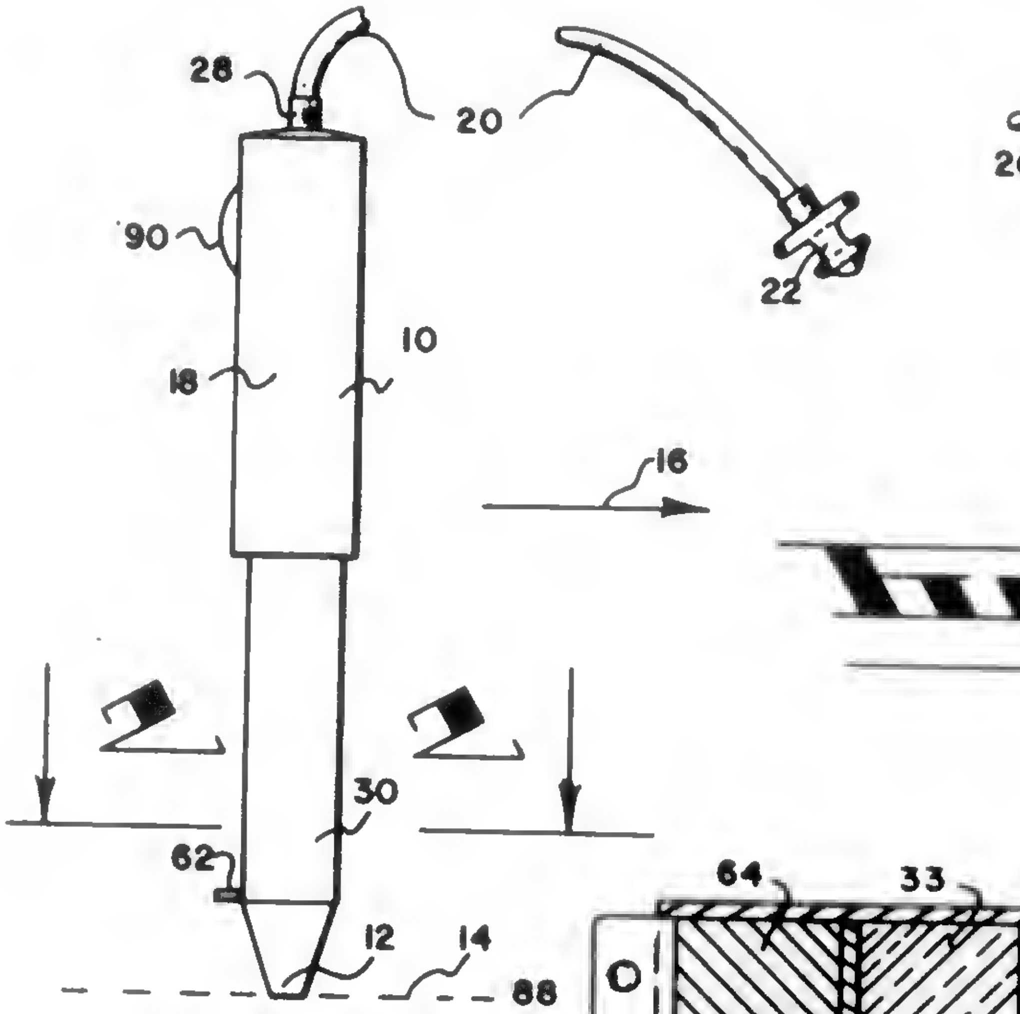

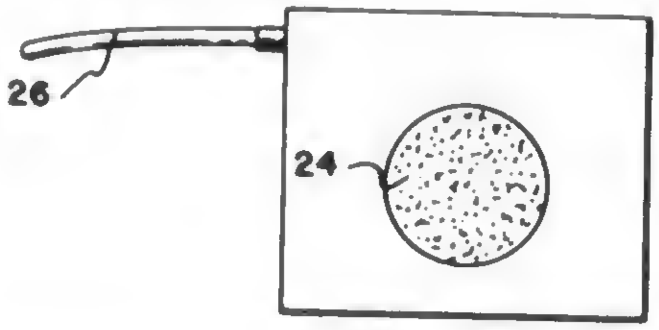

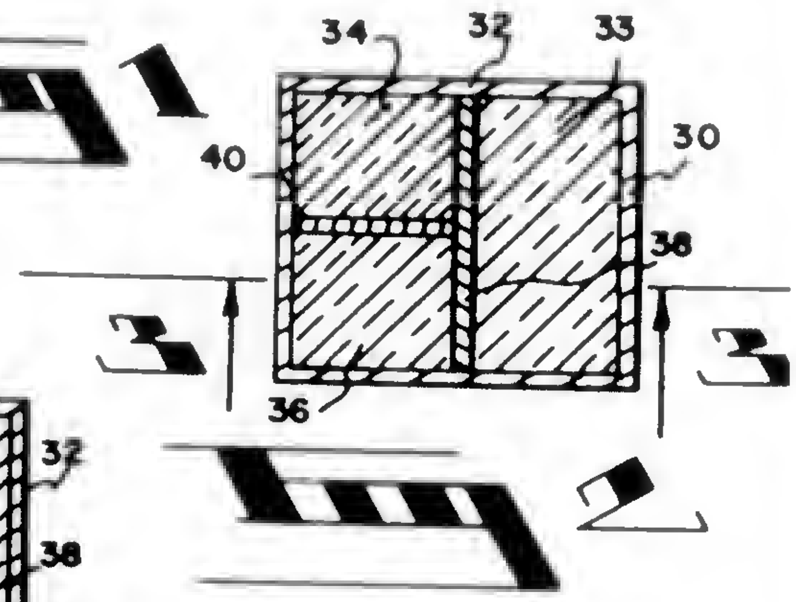

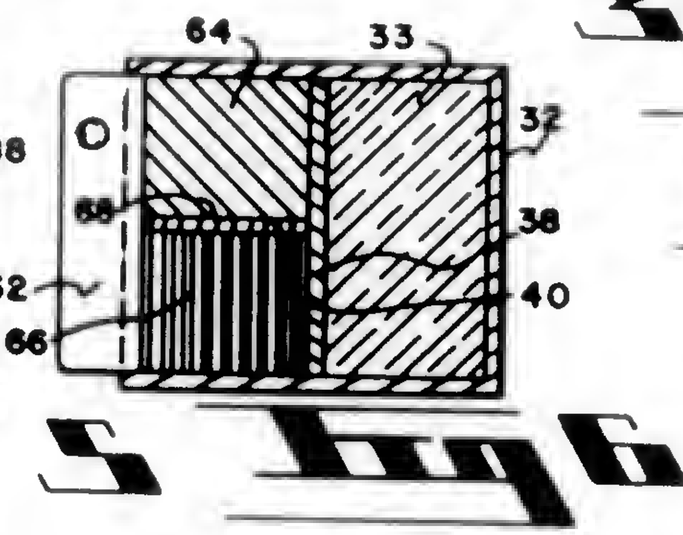

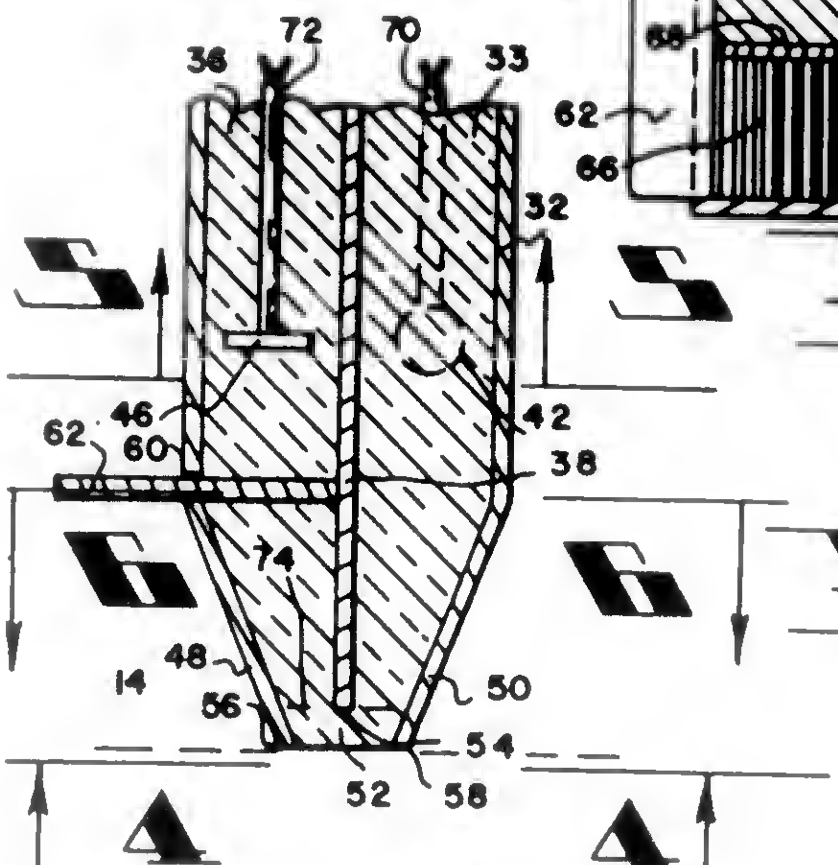

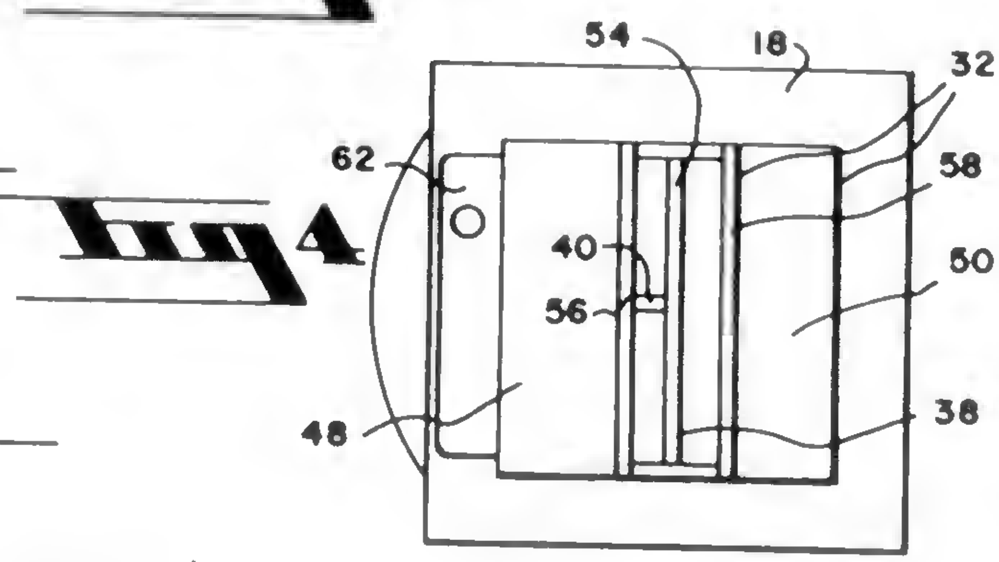

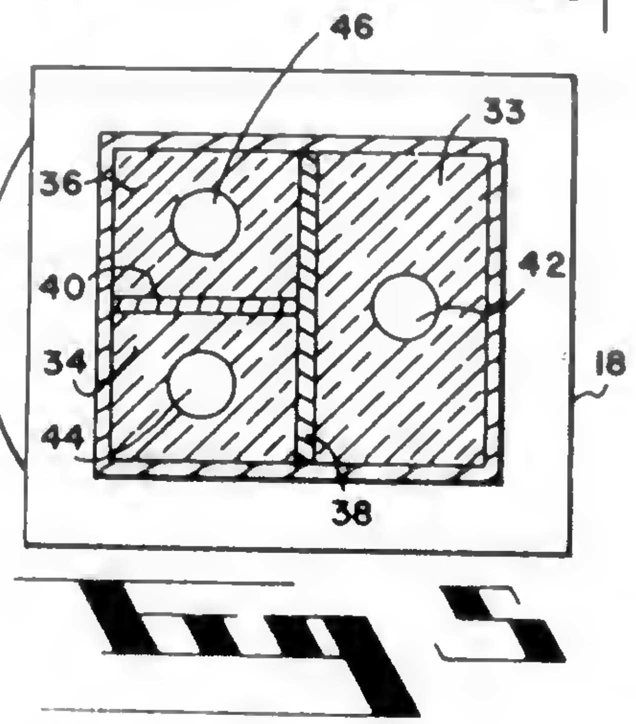

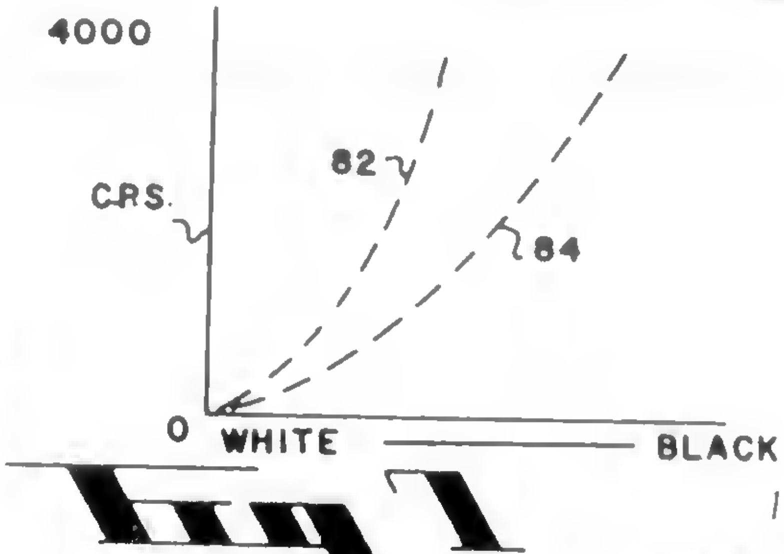

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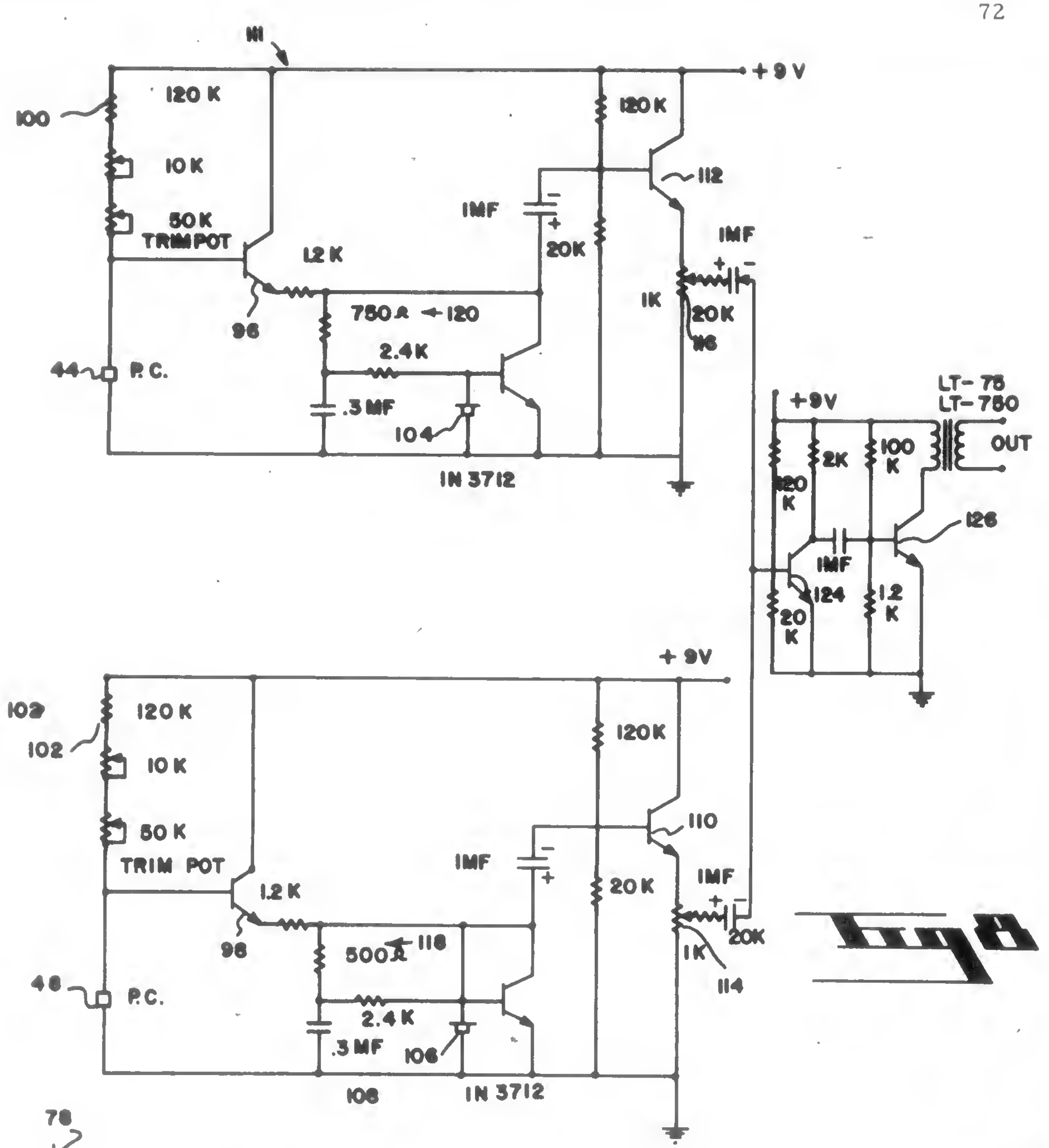

Fig. 8

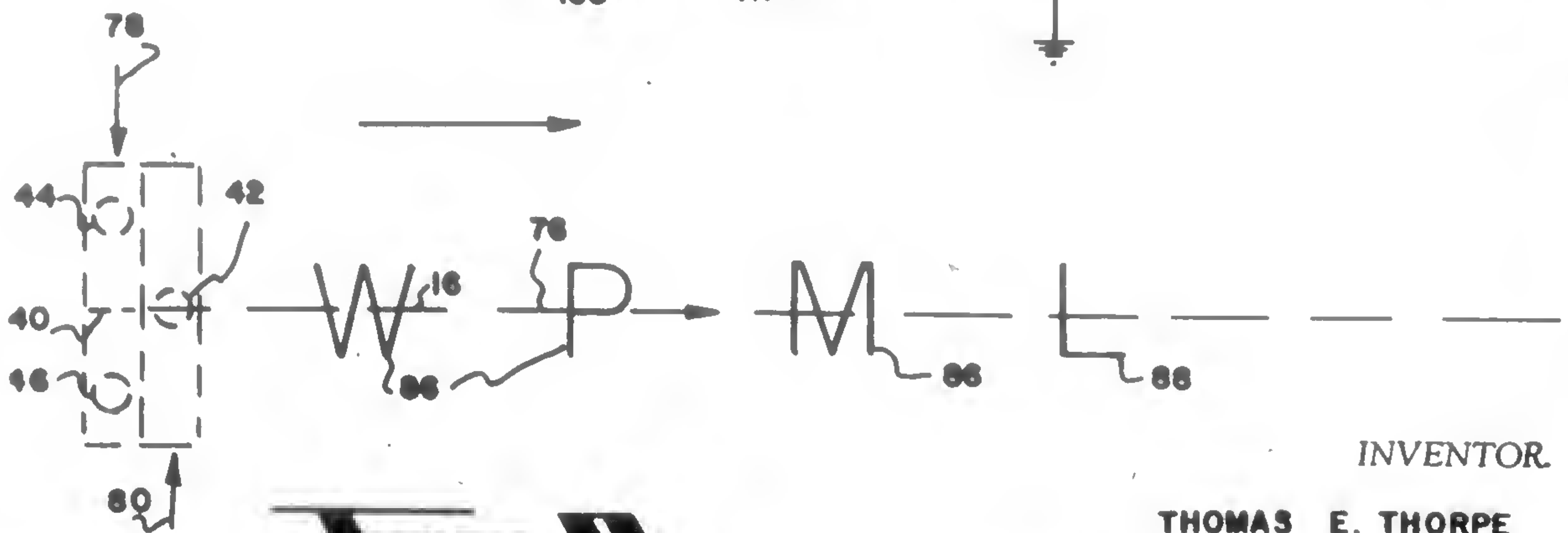

Fig. 9

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